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consisting of a lens cut square like a reading glass, mounted on a light frame provided with a black screen perforated with an eye hole through which the pictures are viewed.

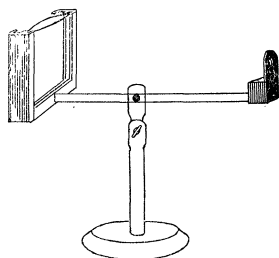


FIG. 4.

The colors are extremely brilliant, and there is a peculiar fascination in the pictures, since, if the viewing apparatus be slowly turned so that its direction with reference to the light varies, the colors change in a most delightful manner, giving us, for example, green roses with red leaves, or blue roses with purple leaves, a feature which should appeal to the impressionists. The reason of this kaleidoscopic effect is evident, for, by turning the viewing apparatus, we bring the eye into different parts of the overlapping spectra.

It is possible to project the pictures by employing a very intense light and placing a projecting lens in place of the eye behind the perforation in the screen. Of course, a very large per cent. of the light is lost; consequently great amplification cannot well be obtained. I have found that sunlight gives the best results, and have thrown up a three-inch picture on a four-foot sheet, so that it could be seen by a fair-sized audience.

By employing a lens of suitable focus it is possible to make the viewing apparatus binocular, for similar sets of superposed spectra are formed on each side of the central image by the gratings, so that we may have two eyeholes if the distance between the spectra corresponds to the interocular distance.

It is interesting to consider that it is theoretically possible to produce one of these diffraction pictures directly in the camera on a single plate. If a photographic plate of fine grain were to be exposed in succession in the camera under red, green and blue screens, on the surfaces of which diffraction gratings had been ruled or photographed, the plate on development should appear as a colored positive when seen in viewing apparatus. I have done this for a single color, but the commercial plates are too coarse-grained to take the impression of more than a single set of lines. With specially-made plates I hope to obtain better results.

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#### THE MENTAL FATIGUE DUE TO SCHOOL WORK.

THE meaning of the results obtained by the different investigators of fatigue among school children has been much confused because either the experimenter has not proved that what he measured was fatigue at all or has so arranged his experiments that the influence of practice on the one hand, and of unwillingness and lack of interest on the other, have not been discounted. Especially when, as has so often been the case, the teacher gives the work as a part of the school routine one may be measuring only a conventional habit of the school children of doing less at a certain time of day, or an unwillingness to work due to ennui. What a person *does* do need not be a measure of what he *could* do.

The experiments a summary of which follows were devised in order to get an answer to the question: "Does the work of a school-session fatigue the pupils mentally, make them really less able to do mental work than they were at its commencement, and, if so, to what extent?"

The method was to give to a sufficient

number of scholars a certain test which would measure their ability (in a certain direction, at least) to do mental work, early in the school session, and then to give this same test to a *different* lot of children of approximately equal general maturity and ability late in the session. The influence of practice is thus entirely obviated, as the scholars do not have the same sort of work twice. In order to save the results from being vitiated by differences in the general ability of the students, four different tests were used, and the pupils who had two of these tests early had the other two late, while those who had the first two late had the other two early. The influence of possible differences in the average ability of the two sets of students can thus be estimated. In order to make sure that the willingness and interest of the pupils was a constant except in so far as due to causes outside our control, all the tests were given by myself.

The work given was: (1) a set of multiplication examples to be done in a given time; (2) a page of printed matter full of mis-spelled words which were to be marked in a given time; (3) two sets of nonsense syllables to be written from memory after a ten seconds' look at them, and (4) two sets of figures and one set of simple forms (*e. g.*, square, triangle) to be written from memory in the same way.

About 150 children (four classes) were given 1 and 3 early and 2 and 4 late. An equal number of children in the same school grade were given 2 and 4 early in the school day, the other half late. In order to eliminate the influence on the work which excitement at my first visit, or being used to me or being tired of me at my second visit, might cause, I made my first visit coincide with an early test in half the classes and with a late test in the other half. The early tests were all given between 10 minutes and 40 minutes after the opening of school in

the morning, while the late tests were given between 40 minutes and 10 minutes before the close of school, half of them at the close of the morning and half at the close of the afternoon session.

Thus any general decrease in the amount or accuracy of the late work will be due to mental fatigue, or to some aversion to work caused by the school day and quite apart from the aversion to conventional routine work or to some factors yet to be demonstrated. And if there is no difference we can say with assurance that the day's work has not decreased the child's ability to work, that though he may in school do less in the latter part of the day it is not in any wise due to real exhaustion, to a lowering of his mental energy.

As a fact what difference there was between the early and late work was in favor of the *latter*. The multiplication test was given to 152 scholars early and 144 late. After reducing the amount done and mistakes made by the 152 to what would have been done by 144, and comparing the results obtained with the work of the 144 who had the test late, we find that the latter did nearly 14% more work and made less than 5% more mistakes.

The spelling work was given to 152 pupils early and 146 late. After estimating the work of 146 early pupils on the basis of what the 152 did and comparing with the 146 late, we find that the latter worked through  $99\frac{7}{10}\%$  as many lines, marked about 2% more words and marked  $2\frac{6}{10}\%$  more words which should have been left unmarked.

The nonsense syllables were used with 152 pupils early and 148 pupils late. When reduced to an equality in numbers the late pupils did  $97\frac{5}{10}\%$  as well as the early.

The figures to be remembered were given to 152 pupils early and 145 late. When reduced to an equality in numbers the late pupils did 89% as well as the early.

In remembering the simple forms the late pupils did  $94\frac{6}{10}\%$  as well as the early.

It seems clear that the mental work of the school day does not produce any marked decrease in the ability to do further work. The data here given are somewhat influenced by certain factors, though not by practice. These factors will be fully discussed in a later report.

The multiplication, spelling and figure tests when given to about 300 children in another city showed the following results:

The multiplication test was given to 156 children early and to 154 later. When evaluated for 153 children the results show the latter to have done  $86\frac{2}{3}\%$  as much work, to have made  $14\frac{7}{10}\%$  more mistakes. Taking together the work of all the children tested (594, 297 early, 297 late), we find that the children who did the work late did  $2\frac{9}{10}\%$  more work, and made exactly the same number of mistakes.

The spelling test was given to 135 early and 128 late. When evaluated for 127 children the results show the latter to have worked through  $92\frac{7}{10}\%$  as many lines, to have marked  $\frac{9}{10}$  of 1 % more words, and to have marked wrongly 87 % as many words. Taking together the work of all the children tested, we find that those who did the work late worked through  $94\frac{9}{10}\%$  as many lines, marked  $1\frac{5}{10}\%$  more words and marked wrongly  $93\frac{7}{10}\%$  as many.

The figure test was given to 156 children early and to 152 late. After reducing the results of the 156 to a basis of 152 we find that those who had the tests late did 17 % better.

Taking together the work of all the children tested, we find that those who had the test late did almost 2 % better than those who had it early.

Besides these three tests, which are of the same sort as some of those given to the first lot of children, there was given to this second lot a test with letters similar to the

figure test. This test was given to 140 children early and to an equal number late. Those doing the work late did 97 % as well as those who had it early.

The factors mentioned as influencing the work of the first set of children were largely counterbalanced by factors at work in the second; one, however, should be mentioned. A certain circumstance probably lessened the work of one class (of 30) of the first lot of children during an early spelling test. So the early work in this test should probably be reckoned about 2 % higher. On the whole these additional data render more probable our previous conclusion that "the mental work of the school day does not produce any decrease in the ability to do mental work." A glance at the following table, which summarizes the more important data, shows this better perhaps than the detailed accounts already given.

Test.	No. of Scholars Tested.	Ratio of Late to Early Work.
Multiplication.	297	$102\frac{9}{10}\%$
Spelling.	273	$101\frac{5}{10}\%$
Figures.	295	102 %
Nonsense syllables.	147	98 %
Form.	145	$94\frac{8}{10}\%$
Letters.	140	99 %

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#### THE INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE.

##### PHYSICS.

THE plan proposed is to issue a book catalogue once in five years, arranged according to both subjects and authors, and to issue also, from week to week, two sets of card catalogues—one according to subjects and the other according to authors. Estimates are given of the proposed cost of this; and various alternatives are proposed, such as the issuing of a book catalogue by itself, or a book catalogue and an author card catalogue. It is estimated that each arti-